Vocational Education and Training in the Age of Digitization

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Vocational Education and Training in the Age of Digitization

Challenges and Opportunities

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Editorial and Introduction to the Volume

Editorial: Vocational Education and Training in the Age of Digitization—Challenges and Opportunities

In the current discussion on digitization, it is assumed that a technological development thrust is currently taking place that brings with it both—opportunities and challenges. On the one hand, completely new technological usage potentials are opening up; on the other hand, these changes pose major challenges to the skills and competencies of (future) employees and—in the consequence—to education and training. In the case of changing and increasing requirements, vocational education and training (VET), as well as further training, will become decisive in order to continuously develop competencies. However, vocational training institutions themselves are also affected by digital change and must make the best possible use of the potential of new technologies. The task of research is to analyse the changes and support the development of strategies, concepts, and models so that individuals, companies, and national economies can benefit from the potential of digitization and at the same time learn to deal with the increasing ambivalences of the technological and social development.

The contributions in this volume will concentrate on challenges and opportunities of digitization for work and workplace learning as well as for vocational education and (further) training. Theoretical approaches, empirical findings and research-based best practice examples of digitization in workplace-related learning are discussed here. When we planned this book, digitization had already been an issue in science and practice for many years (see the introduction by *Helmut M. Niegemann* in this volume). Both had been discussed for quite a while and in an increasingly intensive manner in the contexts of learning, education, and working. What we couldn't know at the time was how relevant this topic would become in a short while. Now that we are writing this preface, we have been in the pandemic for several months, schools and universities are largely doing without classroom teaching, and in-house trainings in companies are suspended or changed to virtual trainings. Teachers, students, trainers and learners had to adapt quickly. In the last months, we have often heard that the educational landscape will be different in the future. In this context, reference is made to the increasing use and the many advantages of technology-based learning and working. Of course we do not know how much the education and training landscape will change and to what extent technology-based learning and working will increase. The fact is that education and training was already quite digitalised before the pandemic and this will most certainly increase further.

Against this background, the contributions in this volume take up the digitization theme from various perspectives which can be found in four sections of the book (Section I: Vocational Education and Training in the Age of Digitization; Section II: Teacher Education and Professional Competencies of Teachers in the Age of Digitization; Section III: Workplace Learning in the Age of Digitization; Section IV: Higher Education in the Age of Digitization). The four sections are framed by an introduction (*Helmut M. Niegemann*) and a final chapter (*Stephen Billet*).

In the introduction, *Helmut M. Niegemann* looks back at the development of educational technologies. He states that a sustainable and systematic integration of digital media into classrooms is still not the standard today and highlights the potentials of technology-based simulations for training and learning as well as for the implementation of valid methods for the assessment of competencies.

The first section of the volume is dedicated to selected technology related issues concerning initial education and training in the professions. In their contribution, *Michael J. J. Roll* and *Dirk Ifenthaler* discuss the potentials of Learning Factories for the development of digital competencies. They conducted an interview study with 19 teachers from German technical vocational schools and asked them about the impact of digitization and Industry 4.0 for their technical vocational school and the potentials of Learning Factories for teaching and learning. Their findings highlight the importance of structured implementation of Learning Factories and the preparation of all stakeholders for Industry 4.0 processes on organisational and staff level in vocational schools.

Mareike Schmidt, Alina Makhkamova, Jan Spilski, Matthias Berg, Martin Pietschmann, Jan-Philipp Exner, Daniel Rugel, and *Thomas Lachmann* focus on the competence development by using digital learning stations in VET in the crafts sector in Germany. In doing so, they created domain-specific digital learning stations (DLS's in a VR environment) based on core work processes of plasterers, integrated them in master preparatory courses and evaluated learner acceptance and learning transfer. The findings of their evaluation studies highlight the potentials of the DLS-learning environment, but also show some challenges for trainees and trainers.

Within their study, *Christin Siegfried* and *Rico Hermkes* analyse the effects of the use of tablet PCs in economics classes in German Vocational Schools. They focus on the motivational experiences and cognitive load of students and compare the results from a digital and an analogue setting. For more information about learning processes, learners' motivation and cognitive load, they use the continuous state sampling method. Among other results, the analyses show that the use of digital media leads to positive experiences of motivation. *Silke Fischer* and *Antje Barabasch* deal in their contribution with the learning potential of gamification in VET. They put the emphasis on the didactical implementation of 21st Century Skills such as communication and cooperation, creativity and critical thinking in gamification and propose a four steps-approach for VET teachers to support the implementation of gamification in classrooms.

The two contributions of Section II deal with different aspects related to teacher education and teachers' professional competencies. The paper by *Andrea Faath-Becker* and *Felix Walker* is entitled "Development of a Video-based Test Instrument for the Assessment of Professional Competence in the Vocational Teacher Training Course". Based on a discussion of different models of teachers' professional competencies, the authors describe the design of video vignettes and discuss the potential of the video vignette tool for the assessment of teachers' competencies. The video vignettes are designed for the industrial-technical field of teacher training in Germany.

The contribution by *Pia Schäfer, Nico Link* and *Felix Walker* also deals with the assessment of professional knowledge of teachers at vocational schools in the domain of automation and digitized production. They base their argumentation on the TPACK-model (TPACK: technological pedagogical content knowledge) by Mishra and Koehler (2006) and report the positive findings of an evaluation study on the effects of a teacher training on automation technology.

The third section of the present volume focuses on contributions to the relevance of digitization for workplace learning. *Henrike Peiffer, Isabelle Schmidt, Thomas Ellwart* and *Anna-Sophie Ulfert,* discuss digital competencies in the workplace to gain an understanding of what they comprise. They shed light on a specific facet of digital competencies, namely digital competence beliefs. Furthermore, the authors investigate how positive competence beliefs can be promoted through trainings. In doing so, they refer to previous studies that investigated and evaluated different training approaches. The article by *Andreas Korbach* and *Helmut M. Niegemann* deals with the potential of a micro-learning approach (the learning content is available on smartphones) for professional drivers. According to the authors, one of the strongest advantages of micro-content might be its high flexibility concerning individual requirements and time constraints. The design of the learning environment is shown in the paper.

Finally, Section IV is dedicated to higher education. Massive Open Online Courses (MOOCs) have been a remarkable phenomenon in educational technology over the last ten years and attracted a lot of attention. Against this background, *Kristina Kögler, Marc Egloffstein* and *Brigitte Schönberger* first discuss current notions of openness in online education and training and show possible links to generic MOOC models. Then the authors present findings from a review-study comprising about three hundred MOOCs from nine common English-speaking providers. Based on the empirical data, the authors characterise different types of MOOCs with a view to their openness.

Victor M. Hernandez-Gantes and *Edward C. Fletcher* discuss the high school career academy as a model for promoting technological preparation in the United States. The goal of the contribution is to conduct a holistic analysis of the career academy model. The analysis of the authors is based on the results of a three-year study designed to explore how IT career academies with different configurations were implemented, with emphasis on the challenges and opportunities in enabling students to become college and career ready. The results of the qualitative study conducted by the authors are very promising.

Finally, Stephen Billett's contribution entitled "Developing a skillful and adaptable workforce: Reappraising curriculum and pedagogies for vocational education" can very well serve as a kind of summary. Billett argues, that changes in occupational and workplace requirements as well as in working life in the era of digitization prompt a reappraisal of the goals and processes of vocational education. These changes include (1) addressing the specific requirements of workplaces and developing occupational competence, and (2) learning knowledge that is difficult to directly experience (e.g. digital knowledge) required for what is often referred to as knowledge work. Billett stresses that there is a need for vocational education and training to respond to this challenge. This includes preparing students to become active and intentional learners for their initial preparation and ongoing development across working life. The author proposes some ways forward by adopting curriculum and pedagogic practices aligned with achieving these kinds of outcomes. This includes considerations of what constitutes effective educational experiences (within both educational institutions and workplaces), ordering and reconciling these two sets of experiences, the use of educational interventions to secure these kinds of capacities within vocational education, including digitized knowledge. This requires accounting for what constitutes existing and emerging occupational and workplace performance requirements and aligning these with the kinds of curriculum and pedagogic practices that vocational education institutions and educators need to advance in an era of digitization.

The papers in this volume represent different approaches to deal with the potentials and challenges of digitization in different areas of education, learning and training. In this book, theoretical approaches and empirical findings are presented in four sections. Thus, this volume provides both a theoretical as well as an empirical basis. It becomes apparent that the approaches are diverse and include many different aspects. However, the contributions also make clear that the trend towards digitization increasingly requires an alignment of learning objectives (which competences should be promoted?), instruction (how can these competences be promoted?), and assessment (how can these competences be assessed?). All actors in vocational education and training are called upon to take up the challenges of digitization and to develop constructive solutions. We also need more research on the potentials and effects of digitization—an evidence-based debate will help us here.

Last but not least, we would like to thank a number of people and institutions who were very important in the creation of this volume. First, we would like to thank the authors for their contributions. We would also like to thank the Budrich publishing house for the constructive cooperation. Many thanks to the Goethe-University Open-Access-Publication-Fund that finances the open-access publication of our volume. Thanks also to the reviewers, who examined the contributions received in a carefully manner and provided many constructive suggestions for improving the papers. Finally, we would like to thank *Teresa Giek* and *Antonia Steffen* for their efforts in formatting the contributions.

Frankfurt and Mannheim, September 2020

Eveline Wuttke, Jürgen Seifried, and *Helmut M. Niegemann*

1 Introduction—A Look Back Ahead

Helmut M. Niegemann

„Books will soon be obsolete in the public schools. Scholars will be instructed through the eye. It is possible to teach every branch of human knowledge with the motion picture. Our school system will be completely changed inside of ten years". This statement by Thomas A. Edison in 1913 (Smith, 1913) was the first, and perhaps the most prominent forecast on the development of media for education which failed monumentally, but not the last. About sixty years later (1971), Helmar Frank and Brigitte Meder, both internationally renowned scholars in the domain of educational technology, predicted a fast triumph of computer supported teaching and learning during the following ten years; almost 100 percent of lessons in general education system's schools would be supported by computers.

New technologies in combination with the financial interests of the companies producing them seem to produce hypes, which are characterised by excessively high expectations, an initial exponential incline over a short period of time, followed by a harsh decline, and—sometimes, but not always—a rather slow increase more closely associated with realistic expectations.

Taking a look back at the development and propagation of the "new media" of the times we see *visual* and *audio-visual media* (especially the educational film) emerging in first half of the last century, followed by *computer based* or *assisted trainings*, arising in the 1960s, declining in the 1970s and their resurrection since the 1990s. In the 1980s both the *teletext* technology (in Germany labeled *„btx"*, in France *„minitel"*) as well as the *video disc* experienced a short hype.

After the invention of the World Wide Web in 1990 and its unforeseen advancement, which penetrated almost all aspects of society *computer-based trainings* (CBT) became at first just *web-based training*s (WBT). However, new information and communication technologies soon promoted the ideas of *intelligent tutoring systems* (ITS), *simulation systems* and *serious games*, *virtual* (VR), *augmented* (AR) and *mixed reality* (MR) in the education sector. With the emergence of truly mobile devices, such as smartphones and tablet computers, *mobile learning* could take off after a somewhat bumpy start with notebooks at the beginning of this century.

Nevertheless, a sustainable and systematic integration of digital media into classrooms is, even more than hundred years after Edison and fifty years after H. Franks prognoses, not the standard; even when due to the CoViD19 pandemic in 2020 a considerable amount of instruction through digital media is suddenly taking place almost worldwide. Whether this exceptional event will put digital media sustainably into our classrooms and everyday practice, remains to be seen.

Different from public schools, in vocational education and training (VET) digital media has been implemented continuously since the 1980s when personal computers captured the office desktops in bigger companies and organisations and the costs of information technologies sank steadily while its performance grew. Setbacks in some companies occurred partly due to the poor quality of the instructional design of several products, but still the e-learning market grew steadily. Let us have a more detailed look at some specific technologies and the factors which contributed to their success.

Skinners *programmed instruction* (at first without any idea of computers) profited from the "sputnik shock", the impression that the political and economic enemy had an advantage in technological development due to a better educational system, after 1957. The computer technology of the early 1960s should have helped to overcome the organisational challenges of the instructional technology, especially when *programmed instruction* left the strict theoretical rules of operational conditioning by introducing branching (Crowder, 1959) and other features. This early computer assisted learning, using dedicated connections between central computers and the displays, was quite expensive. So, concerning public schools the hype faded away when alternative political topics (such as the war in Vietnam) prevailed over educational matters and required more and more money. Organisations and institutions dedicated to educational technology research and development were closed at the end of the 1970s. But military and big companies maintained educational technology until the advent of the personal computer in 1980. The new high disposability of the devices opened new opportunities and a new wave of computer-based training and instruction began, using color displays, higher capacities on data carriers, and authoring tools (e.g. Toolbook®, Macromedia Director®) to develop e-learning programs by vocational trainers without the help of professional programmers. A not negligible part of the success may be due to the need for training in the new office application software (text processing, spreadsheet calculation etc.). Some ideas originating from that time actually succeeded albeit at a much later time (e.g. electronic performance support systems—ePSS; a combination of short computer-based explanations or training units, and tools to facilitate work, e.g. pre-organised Excel sheets).

The next emerging condition fostering instructional technology was the internet. Since 1990 and the world wide web, which initially allowed for the communication of an increasing amount of data to many recipients, then the two-way communication including the streaming of video data companies have been able to adapt and correct E-learning units just in time. As companies are no longer forced to send CDs and DVDs with e-learning units by mail to their foreign subsidiaries in all continents in order to convey new features of their software releases (e.g. SAP SE).

While video conferencing has been possible earlier via rather expensive satellite channels, the technology became inexpensive and available for everybody, not only could students learn from Youtube videos, blended learning formats like “flipped classroom” were introduced in continuous education and trainings. Video communication reached a peak in 2020 when the corona crisis forced millions of people worldwide to communicate, negotiate and teach at home, as offices, schools and universities began using these tools extensively.

The same technology also allows to distribute lectures of renowned experts from elite universities (e.g. computer scientist Sebastian Thrun from Stanford University in 2011) to a very large audience and to establish the massive open online courses (*MOOCs*), becoming an initially hyped movement ,which seems to have found some stable structures within specialised companies. The acceptance and effectivity of MOOCs soon proved to be better using short video units (*“mini-lectures”).* Although we do not have clear results from psychological research concerning the endurance or depletion of learners listening and studying in front of a display, everyday experience shows, that 60- or 90-minutes video lectures are generally less accepted than mini-lectures of 10 to 20 minutes.

With the rise of the laptop, and later notebook computers (market-relevant since the 1990s, booming around the turn of the millennium), then smartphones and tablets (market-relevant since 2007 resp. 2010) *mobile learning* became a trend. Despite hopes and expectations that tablets would replace the bundle of heavy textbooks, pupils have to carry daily to school (especially in German speaking countries), even in most developed countries there are only scattered “tablet classes” or even “tablet schools”. Smartphones, which are owned by more than 95% of students in Germany, are often forbidden during lessons due to fears of undesirable use. Again, the use of the mobile instructional technologies took root in business and industry. Especially smartphones became an important tool for *MOOCs* and other forms of micro-learning offers. The rather small displays barely allow for listening to long lessons or to read long texts but are well accepted for quick lessons and video resp. multimedia instruction.

Rather early in the history of the personal computer users liked to use it not only for work, but also for playing games. This fact led soon to the idea to use games for the purpose of learning, especially to foster a kind of motivation transfer from the joy of playing to learning. Indeed, a lot of studies show that *digital games for learning (“serious games”*) can convey important ideas from several curricula in schools, in business and in the military. In case of specific psycho motoric as well as problem solving skills, it is evident that exercises in simulated, more or less authentic situations work as exercises and therefore foster learning. Many science issues, coding skills, mathematical, technical, economical abilities and even historic knowledge can be learned through well-designed games for learning. But there are limits to their usage, which game-based learning enthusiasts (e.g. Prensky, 2001) seem to neglect: *Serious games* take a lot of time to convey a specific subject matter, much more time than most other formats of instruction and the development of high-quality games for learning are expensive. The loss of time is a consequence of the cover story, in which the subject matter in good cases is integrated, or in worse cases is just associated in some way. Thus, the use of games for learning in schools is uncommon.

Mostly at the core of a serious game is a simulation, even if the simulated reality is more or less fictional. Decisive for the efficiency of learning is the similarity of the cognitive and/or the psycho motoric operations executed in the simulated environment and the operations to be executed in real situations. Hence, classical simulation devices (flight simulators, truck simulators, boat simulators, etc.) as well as business games try to immerse the learners into an environment as authentic as possible. Although all newer realisations of these simulations use electronics, the really new ways to use simulated experiences for instruction are via Augmented Reality (AR), *V*irtual Reality (VR) and Mixed Reality (MR), especially for vocational education and training in technical and medical domains. The challenge here is on the one hand the amount of authenticity—a technical problem—and the instructional design of valid learning tasks and exercises on the other including the quality of the feedback for the individual learners. Individualisation means adaptivity and requires interactivity. Two of the big promises of digital learning over the last sixty years are the ability to individualise the learning experience and the ability for participants to set their own learning pace due to the flexibility and lack of time restrictions.

Similar to the individualisation in commerce by finding patterns of individual consumer behavior based on data from online shopping or customer cards there are some possibilities to get information from learners' online behavior: time variables, clicking behavior, input, navigation etc. are used for *learning analytics*. Until today it is still not clear whether this *artificial intelligence (AI)* technology will succeed in the domain of learning as long as the human-computer communication is mostly restricted to mouse clicks, fingertips on a touch screen or the input of words or numbers. Domains in educational technology where AI has proven itself to function technically and psychologically are *intelligent tutoring systems (ITS)*, e.g. "Active Math" (Melis & Siekmann, 2004) or "Autotutor" (Nye, Graesser, & Hu, 2014), and *automatic grading systems* (Landauer, Graham, & Foltz, 2000), but unfortunately both areas are up until now not successful in the market.

Last but not least the domain of *technology-based assessment* enabled primarily the area of VET with more efficient and more valid methods to assess complex competencies by methods, such as *adaptive testing* and the use of rather *authentic virtual task environments*.

Overall educational technology has made a lot of progress over the 100 years the discipline has existed. Even though the public discussion was often focussed on the use of technology in schools, the vocational education and training field seems to benefit much more, presumably because educational technology aims primarily to improve the efficiency of learning processes and to foster flexibility, while schools have to strive additionally for objectives, which also need other kinds of support.

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